Errata Sheet

EPA 430-R-04-006 (June 2004)

30 December 2004

This errata sheet lists corrections and elaboration on points discussed in U.S. EPA 430-R-04-006 (June 2004), *Analysis of Costs to Abate International Ozone-Depleting Substance Substitute Emissions*. This errata sheet highlights the major updates that are being made based on new information provided after the original analysis was performed, and discusses how these updates affect various data and results presented in the report. Summaries of the major changes are provided first, indicating the pertinent chapter. Following these summaries are revised tables, with data from the June 2004 report that has changed shown in strikeout format, that illustrate how the overall results are affected. For complete updated results, the reader is encouraged to refer to future U.S. EPA reports on global emissions of non-CO_2 greenhouse gases and costs to abate those emissions.

MAJOR CHANGES

- Foams: As noted in the original report, the emissions from appliance foam at disposal are dependent upon how the discarded foam is handled and processed. Research indicates that the amount of HFC content remaining in appliance foam is <u>not</u> released instantaneously upon disposal/shredding. Rather, only approximately between 20% and 40% of the HFC content is emitted at the time of shredding, depending on the size of shredded particles. The assumption that 100% of the remaining blowing agent (or 92.25% of the original amount) is emitted at disposal was changed. Instead, it is assumed that 30% of the remaining blowing agent (27.675% of the original amount) is emitted at disposal. Although the remaining amount might still be emitted over time (e.g., as the blowing agent diffuses from the foam and out of a landfill), the model was not capable of tracking those emissions and hence those emissions are not included in the baseline estimates. Additional research is underway to confirm the 30% estimate, but the results were not available to use in these revisions. Baseline emissions from this foams end-use were reduced, relative to the baselines listed in the June 2004 report, for the years 2015 and 2020 (no appliance foam containing HFC blowing agents was assumed to be disposed in 2005 or 2010).
- Foams: The above change also affected the emissions in 2015 and 2020 abatable by the end-of-life options. While the actual amount of emissions abated at the time of disposal (i.e., the amount of HFC blowing agent destroyed) is the same, the above change implies that the amount that would be abated from the baseline emissions in a given year is lower. Because the model was not capable of tracking emissions after disposal, those emissions are not included in the estimates of emissions reduced by the end-of-life options analyzed. This change therefore decreased the emissions abated by these options.
- Foams: New information on the costs associated with appliance foam end-of-life options has been received, which increased the marginal abatement costs ($/TCE) of these options.
- Foams: Based on Mutton and Lee (Earth Technologies Forum, 2004) and Vo and Paquet (Earth Technologies Forum, 2004), the emission function of extruded polystyrene (XPS)

boardstock foam was changed. A slower release rate and longer lifetime[1] were assumed, thus decreasing baseline emissions from this end-use from all countries where emissions were assumed to exist.

- Foams: New information was obtained on the XPS market that changed the options analyzed. It was decided that the conversion to pure CO_2 was not a likely option and so was removed from the report. The conversion to CO_2/Alcohol remained, with a typographical error in the assumed market penetration fixed, and with the previous market penetration of both options now attributed to this one option. The emissions abated by the option in non-U.S. Annex I countries also changed based on the change in emission baselines (emission abated in the U.S. and non-Annex I countries remained zero). Also, new information on capital and annual costs associated with this option was used. Overall, the marginal abatement cost ($/TCE) of this option increased.
- Fire Extinguishing: The U.S. Vintaging Model was revised to reflect the continued availability and use of halons after the original system is decommissioned. Also, the average emission rate was revised from 1.5% to 2.0% based on Verdonik et al. (Earth Technologies Forum, 2004). Finally, the original market size information contained in the Vintaging Model was updated to reflect market data published in the UNEP 2002 Assessment Report of the Halons Technical Options Committee. Overall, these changes resulted in lower baseline U.S. emissions, and hence lower emission savings of the various options in the U.S.
- Fire Extinguishing: New market transition data was provided for Europe, allowing us to create custom vintaging models for these countries. The baseline emissions changed in two ways: (1) baseline emission estimates decreased generally except in 2020 when they were slightly higher, and (2) the trend of decreasing baseline emissions was reversed such that emissions now are estimated to increase over time.
- Fire Extinguishing: The costs used to evaluate the abatement options were reevaluated. It was discovered that the different sources that were originally used reflected costs at different times. Because of the dynamic nature of this market (for example, the amount of HFC-227ea agent required to protect against Class A hazards has decreased approximately 11%, and the cost of the agent has decreased approximately 30%, in just one year), we decided to use agent costs from August 2003, provided by Bob Wickham in a letter dated August 11, 2004. These agent costs were used to support overall installation cost estimates published in an August 2003 report, which was and continues to be used in our analysis. Also, the costs and emission savings were adjusted to reflect the new 2.0% average emission rate. Overall, the marginal abatement costs ($/TCE) of the options declined.
- Solvents: New information was obtained on the use of HFEs in the solvents sector. Industry experts felt that a more likely mix of the use of HFEs as substitutes for HFC and PFC solvents which in turn are used as ozone-depleting substance (ODS) substitutes, would be approximately 75% HFE-7100 and 25% HFE-7200. Hence, the nominal GWP of HFE was changed from 222.5, which was based on a 50/50 mix of HFE-7100 and HFE-7200, to 306.25. This increased the reduction efficiency and increased emissions savings of the "Conversion to HFE Solvents" option, but did not affect the price.

[1] Loss at foam end-of-life was also modified; however, because of the long lifetime assumed for this foam type, disposal emissions do not occur within the timeframe of the analysis.

- Solvents: The U.S. use of PFCs as substitutes to ODSs was revised to assume a decrease to zero by 2010, based on information provided by chemical manufacturers and industry experts. This decreased baseline emission estimates for the U.S. slightly.
- Solvents: Some PFC use as ODS substitutes for precision cleaning in countries other than the U.S. was assumed by estimating the total global PFC use in 2000, and assuming a linear decrease in use to zero by 2015, based on information provided by chemical manufacturers and industry experts. This use was apportioned to non-U.S. countries based on their semiconductor market, which was used as a proxy for circuit board cleaning, a predominant precision cleaning use. This change increased baseline emissions of those countries.
- Solvents: Because changes to the solvents baseline emissions resulted in PFC emissions comprising a large portion of total GWP-weighted emissions for some non-US countries, the technical applicability for the Retrofit and Not-In-Kind (NIK) options was adjusted to 100 percent.
- Solvents: Additionally, the technical applicability for the Conversion to HFEs option was reduced to reflect that HFE emissions were already assumed to comprise some portion of the baseline. For example, since 19% of total solvent U.S. baseline emissions in 2005 are estimated to be HFEs, the technical applicability for this option in 2005 is 81%. This decreased the emission savings of this option.
- Solvents: The GWP of the gas being removed for the Retrofit and NIK options was adjusted to a weighted average of the gases in the baseline, using U.S. data for year 2020. Previously, the GWP of the gas being removed was that of HFC-4310mee; however, because the technical applicability was adjusted to 100%, the GWP was revised accordingly to reflect the mix of gases assumed in the baseline. Overall, the marginal abatement costs ($/TCE) of the retrofit option decreased (i.e., the savings increased) while the costs of the NIK options increased.

NEW TABLES

- Exhibit ES-1 (baseline ODS substitute emissions by sector for 2005-2020).
- Table 3-1 (emission rate profile for foam end-uses).
- Table 3-2 (baseline emissions from foams).
- Tables 3-8, 3-9 and 3-10 (assumptions and costs used in the cost analyses for XPS foams).
- Tables 3-26, 3-27 and 3-28 (foams results of emissions abated in 2020 and $/TCE costs for options in the U.S., Annex I, and non-Annex I).
- Table 4-1 (baseline emissions from fire extinguishing).
- Table 4-7, 4-8 and 4–9 (fire extinguishing results of emissions abated in 2020 and $/TCE costs for options in the U.S., Annex I, and non-Annex I).
- Table 5-2 (baseline emissions from solvents).
- Table 5-6, 5-7 and 5–8 (solvents results of emissions abated in 2020 and $/TCE costs for options in the U.S., Annex I, and non-Annex I).

Exhibit ES-1: Baseline World ODS Substitute High GWP Gas Emissions (MMTCE)				
Source of High GWP Gases Used as ODS Substitutes	2005	2010	2015	2020
Refrigeration and Air-Conditioning	~~59.92~~ 59.90	~~94.50~~ 94.46	~~128.73~~ 128.67	~~158.80~~ 158.73
Partially and Fully Fluorinated Solvents	~~1.07~~ 3.17	~~1.14~~ 2.10	~~1.20~~ 1.13	~~1.26~~ 1.23
Aerosols	12.26	14.44	15.92	17.60
Foams	~~2.94~~ 2.58	~~5.30~~ 4.21	~~7.76~~ 5.64	~~16.38~~ 9.39
Fire Extinguishing	~~2.26~~ 1.01	~~2.26~~ 1.76	~~2.65~~ 2.49	~~3.19~~ 3.24
TOTAL	~~78.45~~ 78.92	~~117.66~~ 116.98	~~156.26~~ 153.84	~~197.23~~ 190.17

Notes:

Forecast assumes a "business-as-usual" scenario as described ~~above~~ in the original report.

The emissions forecast includes only direct emissions. Indirect emissions—those that result from the production of energy required in the manufacturing and operation of the emitting sources—are not included.

Sums might not add to total due to independent rounding.

Table 3-1: U.S. EPA's Vintaging Model Emissions Profile for the Foams End-Use

Foams Sector	Loss at Manufacturing (%)	Annual Release Rate (%)	Release Lifetime (years)	Loss at Disposal (%)	Total Released (%)
Flexible PU	100	0	~~0~~ 1	0	100
Polyisocyanurate Boardstock	6	1	50	44	100
Rigid PU Integral Skin	95	2.5	2	0	100
Rigid PU Appliance	4	0.25	15	~~92.25~~ 18.45-36.9*	~~100~~ 35
Rigid PU Commercial Refrigeration	6	0.25	15	90.25	100
Rigid PU Spray	15	1.5	~~57~~ 56	~~0~~ 1	100
One Component	100	0	~~0~~ 1	0	100
Rigid PU Slabstock and Other	37.5	0.75	15	51.25	100
Phenolic	23	0.875	32	49	100
Polyolefin	95	2.5	2	0	100
XPS Foam Sheet	40	2	25	0	90
XPS Boardstock	25	~~2.5~~ 0.75	~~30~~ 50	~~0~~ 37.5	100
Sandwich Panel	5.5	0.5	50	69.5	100

*for calculation purposes, 27.675% is used.

Table 3-2: Baseline HFC Emission Estimates from Foams (MMTCE)

Regions	2005	2010	2015	2020
United States	0.53	~~1.90~~ 1.52	~~3.15~~ 2.17	~~7.35~~ 3.81
Non-US Annex I	~~2.40~~ 2.05	~~3.40~~ 2.68	~~4.59~~ 3.46	~~9.01~~ 5.57
Non-Annex I	0.00	0.01	0.01	0.01
Total	~~2.94~~ 2.58	~~5.30~~ 4.21	~~7.76~~ 5.64	~~16.38~~ 9.39

Table 3-8: Base Case Assumptions for a Hypothetical ~~Contractor~~ Facility Using HFC-134a/CO_2 (LCD) Based Blowing Agents in XPS Foam

Variable	Value	Source
Blowing Agent Consumption	1,500,000 lb/yr	Estimated from Caleb (2001)
Polystyrene Consumption	2.0 lb/ft^3	Assumption
Foam Produced	8,330,000 ft^3/yr	Assumption
Price of CO_2	$0.20/lb	Airproducts, 2003
Price of HFC-134a	$1.70/lb	Atofina, 2004
Price of Polystyrene	~~$0.40/lb~~ $0.75/lb	~~Purchasing.com,~~ Plastic News, 2004

~~Table 3-9: Assumptions and costs used in the cost analysis to substitute HFC-134a/CO2 with CO2 in XPS Foam~~ -- DELETED

Table 3-10: Assumptions and costs used in the cost analysis to substitute HFC-134a/CO_2 with CO_2/Alcohol in XPS Foam

Variable	Value	Source
Capital Costs	~~$800,000~~ $4,500,000[a]	~~Assumption~~ DOW, 2004
Increase in Foam Density	~~5%~~ 10%	~~Assumption~~ DOW, 2004
Price of Alcohol	$0.65	Purchasing.com

~~[a] Blends with alcohol (e.g., ethanol) require lower pressure extrusion; therefore lower capital than pure CO_2.~~

Table 3-26: Emission Reductions in 2020 and Costs of Abatement for Foams in the US
[Note: changes in Break-Even Prices will result in reordering of this table; therefore revised cumulative reductions are only shown for the last reduction option.]

Reduction Option	Break-Even Price (2000$/TCE) Discount /Tax Rate 4% /0%	Break-Even Price (2000$/TCE) Discount /Tax Rate 20% /40%	Emission Reduction of Option (MMTCE)	Reduction off Baseline (Percent)	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
Spray HFC-245fa/CO2 and HFC-365mfc/HFC-227ea to HC	$(17.97)	$(13.98)	~~0.37~~ 0.27	~~5.1%~~ 7.0%	~~0.37~~	~~5.1%~~
PU One Component HFC-152a to HC	~~$(9.40)~~ $(87.29)	~~$2.77~~ $25.68	~~0.0~~ 0.00	0.0%	~~0.37~~	~~5.1%~~
XPS: HFC-134a/CO2 to CO2/Alcohol	~~$(8.50)~~ $25.56	~~$12.82~~ $171.64	~~0.0~~ 0.00	0.0%	~~0.37~~	~~5.1%~~
PU One Component HFC-134a to HC	$(0.07)	$14.08	0.02	~~0.2%~~ 0.5%	~~0.39~~	~~5.3%~~
~~XPS: HFC-134a/CO2 to CO2~~	~~$11.48~~	~~$122.09~~	~~0.0~~	~~0.0%~~	~~0.39~~	~~5.3%~~
Appliance HFC-134a to HC	$17.35	$404.45	~~0.04~~ 0.03	~~0.5%~~ 0.9%	~~0.43~~	~~5.8%~~
Appliance: Automated Process with Foam Grinding, HFC Adsorption, and Foam Landfilling	~~$23.82~~ $68.67	~~$37.16~~ $102.06	~~0.26~~ 0.08	~~3.5%~~ 2.0%	~~0.69~~	~~9.4%~~
PU Continuous and Discontinuous HFC to HC	$43.83	$56.26	~~0.0~~ 0.02	~~0.0%~~ 0.5%	~~0.69~~	~~9.4%~~
Spray HFC-245fa/CO2 and HFC-365mfc/HFC-227ea to CO2	$96.45	$122.55	~~0.22~~ 0.16	~~3.0%~~ 4.3%	~~0.91~~	~~12.4%~~
Appliance: Manual Process with Foam Incineration	~~$175.09~~ $176.23	~~$191.65~~ $192.78	~~0.78~~ 0.24	~~10.7%~~ 6.2%	~~1.69~~	~~23.0%~~
Appliance HFC-245fa and HFC 365mfc/HCF-227ea to HC	$201.80	$1,115.58	~~0.12~~ 0.11	~~1.6%~~ 2.9%	~~1.81~~ 0.93	~~24.6%~~ 24.4%

Table 3-27: Emission Reductions in 2020 and Costs of Abatement for Foams in the non-US Annex I Countries [Note: changes in Break-Even Prices will result in reordering of this table; therefore revised cumulative reductions are only shown for the last reduction option.]

Reduction Option	Break-Even Price[a] (2000$/TCE) Discount Rate/Tax Rate 4% /0% Low	Break-Even Price[a] (2000$/TCE) Discount Rate/Tax Rate 4% /0% High	Break-Even Price[a] (2000$/TCE) Discount Rate/Tax Rate 20% /40% Low	Break-Even Price[a] (2000$/TCE) Discount Rate/Tax Rate 20% /40% High	Emission Reduction of Option (MMTCE)	Reduction off Baseline (Percent)	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
Spray HFC-245fa/CO2 and HFC-365mfc/HFC-227ea to HC	$(17.97)	$(15.13)	$ (13.98)	$1.53	~~0.09~~ 0.15	~~0.9%~~ 2.8%	~~0.09~~	~~0.9%~~
PU One Component HFC-152a to HC	~~$(9.40)~~ $(87.29)	~~$(9.40)~~ $(87.29)	~~$2.77~~ $25.68	~~$2.77~~ $25.68	~~0.0~~ 0.02	~~0.0%~~ 0.3%	~~0.09~~	~~0.9%~~
XPS: HFC-134a/CO2 to CO2/Alcohol	~~$(8.50)~~ $25.56	~~$(8.50)~~ $25.56	~~$12.82~~ $171.64	~~$12.82~~ $171.64	~~0.0~~ 0.67	~~0.0%~~ 12.1%	~~0.09~~	~~0.9%~~
PU One Component HFC-134a to HC	$(0.07)	$(0.07)	$14.08	$14.08	0.11	~~1.2%~~ 1.9%	~~0.19~~	~~2.1%~~
~~XPS: HFC-134a/CO2 to CO2~~	~~$11.48~~	~~$11.48~~	~~$122.09~~	~~$122.09~~	~~1.70~~	~~18.9%~~	~~1.89~~	~~21.0%~~
Appliance HFC-134a to HC	$17.35	$17.35	$404.45	$404.45	~~0.0~~ 0.00	0.0%	~~1.89~~	~~21.0%~~
Appliance: Automated Process with Foam Grinding, HFC Adsorption, and Foam Landfilling	~~$23.82~~ $68.67	~~$23.82~~ $68.67	~~$37.16~~ $102.06	~~$37.16~~ $102.06	~~1.08~~ 0.63	~~11.9%~~ 11.3%	~~2.97~~	~~32.9%~~
PU Continuous and Discontinuous HFC to HC	$43.83	$43.83	$56.26	$56.26	~~0.0~~ 0.23	~~0.0%~~ 4.2%	~~2.97~~	~~32.9%~~
Spray HFC-245fa/CO2 and HFC-365mfc/HFC-227ea to CO2	$96.45	$96.45	$122.55	$122.55	~~0.12~~ 0.22	~~1.4%~~ 3.9%	~~3.09~~	~~34.3%~~
Appliance: Manual Process with Foam Incineration	~~$175.09~~ $176.23	~~$175.09~~ $176.23	~~$191.65~~ $192.78	~~$191.65~~ $192.78	~~0.01~~ 0.00	~~0.1%~~ 0.0%	~~3.10~~	~~34.4%~~
Appliance HFC-245fa and HFC 365mfc/HCF-227ea to HC	$201.80	$201.80	$1,115.58	$1,115.58	~~0.11~~ 0.33	~~1.2%~~ 5.9%	~~3.20~~ 2.35	~~35.6%~~ 42.3%

[a] Costs vary by country/region based on one-time or annual adjustment factors; therefore, the lowest and highest costs for the region are shown.

Table 3-28: Emission Reductions in 2020 and Costs of Abatement for Foams in non-Annex I Countries
[Note: changes in Break-Even Prices will result in reordering of this table; therefore cumulative reductions are only shown for the last reduction option.]

Reduction Option	Break-Even Price (2000$/TCE) Discount /Tax Rate 4% /0%	20% /40%	Emission Reduction of Option (MMTCE)	Reduction off Baseline (Percent)	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
Spray HFC-245fa/CO2 and HFC-365mfc/HFC-227ea to HC	$(17.97)	$(13.98)	~~0.0~~ 0.00	0.0%	~~0.0~~	~~0.0%~~
PU One Component HFC-152a to HC	~~$(9.40)~~ $(87.29)	~~$2.77~~ $25.68	~~0.0~~ 0.00	0.0%	~~0.0~~	~~0.0%~~
XPS: HFC-134a/CO2 to CO2/Alcohol	~~$(8.50)~~ $25.56	~~$12.82~~ $171.64	~~0.0~~ 0.00	0.0%	~~0.0~~	~~0.0%~~
PU One Component HFC-134a to HC	$(0.07)	$14.08	0.01	100.0%	~~0.01~~	~~100.0%~~
~~XPS: HFC-134a/CO2 to CO2~~	~~$11.48~~	~~$122.09~~	~~0.0~~	~~0.0%~~	~~0.01~~	~~100.0%~~
Appliance HFC-134a to HC	$17.35	$404.45	~~0.0~~ 0.00	0.0%	~~0.01~~	~~100.0%~~
Appliance: Automated Process with Foam Grinding, HFC Adsorption, and Foam Landfilling	~~$23.82~~ $68.67	~~$37.16~~ $102.06	~~0.0~~ 0.00	0.0%	~~0.01~~	~~100.0%~~
PU Continuous and Discontinuous HFC to HC	$43.83	$56.26	~~0.0~~ 0.00	0.0%	~~0.01~~	~~100.0%~~
Spray HFC-245fa/CO2 and HFC-365mfc/HFC-227ea to CO2	$96.45	$122.55	~~0.0~~ 0.00	0.0%	~~0.01~~	~~100.0%~~
Appliance: Manual Process with Foam Incineration	~~$175.09~~ $176.23	~~$191.65~~ $192.78	~~0.0~~ 0.00	0.0%	~~0.01~~	~~100.0%~~
Appliance HFC-245fa and HFC 365mfc/HCF-227ea to HC	$201.80	$1,115.58	~~0.0~~ 0.00	0.0%	0.01	100.0%

* Break-even costs do not vary by country within the Non Annex I region.

Table 4-1: Baseline HFC and PFC Emission Estimates from Fire Extinguishing (MMTCE)

Region	2005	2010	2015	2020
United States	~~0.43~~ 0.34	~~0.65~~ 0.45	~~0.80~~ 0.48	~~0.89~~ 0.52
Non-U.S. Annex I	~~1.51~~ 0.30	~~1.00~~ 0.58	~~0.87~~ 0.82	~~0.94~~ 1.04
Non-Annex I	~~0.31~~ 0.37	~~0.61~~ 0.73	~~0.98~~ 1.19	~~1.37~~ 1.67
Total	~~2.26~~ 1.01	~~2.26~~ 1.76	~~2.65~~ 2.49	~~3.19~~ 3.24

Note: Totals may not sum due to independent rounding.

Table 4-7: United States Emission Reductions in 2020 and Break-Even Costs for Fire Extinguishing

Reduction Option	Break-Even Cost (2000$/TCE) Discount/Tax Rate 4%/0%	20%/40%	Emission Reduction of Option (MMTCE)	Percent Reduction from 2020 Baseline	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
Inert Gases	~~$81.98~~ $54.15	~~$410.54~~ $294.05	~~0.14~~ 0.08	~~15.8%~~ 16.2%	~~0.14~~ 0.08	~~15.8%~~ 16.2%
FK-5-1-12	~~$83.96~~ $74.94	~~$335.63~~ $263.60	~~0.17~~ 0.11	~~19.8%~~ 20.2%	~~0.31~~ 0.19	~~35.6%~~ 36.4%
Water Mist	~~$146.97~~ $97.39	~~$587.31~~ $407.88	~~0.02~~ 0.01	2.3%	~~0.33~~ 0.20	~~37.8%~~ 38.7%

Table 4-8: Non-U.S. Annex I Emission Reductions in 2020 and Break-Even Costs for Fire Extinguishing

Reduction Option	Break-Even Cost (2000$/TCE)[a] Discount/Tax Rate 4%/0% Low	4%/0% High	20%/40% Low	20%/40% High	Emission Reduction of Option (MMTCE)	Percent Reduction from 2020 Baseline	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
FK-5-1-12	~~$83.72~~ $74.78	~~$85.22~~ $75.90	~~$334.91~~ $263.16	~~$336.75~~ $264.47	~~0.19~~ 0.21	~~19.8%~~ 20.2%	~~0.19~~ 0.21	~~19.8%~~ 20.2%
Inert Gases	~~$71.10~~ $47.63	~~$136.29~~ $94.70	~~$369.25~~ $271.21	~~$483.77~~ $340.16	~~0.15~~ 0.17	~~15.8%~~ 16.2%	~~0.33~~ 0.38	~~35.6%~~ 36.4%
Water Mist	~~$111.76~~ $78.21	~~$287.80~~ $200.94	~~$467.17~~ $343.94	~~$761.31~~ $500.29	0.02	2.3%	~~0.36~~ 0.40	~~37.8%~~ 38.7%

[a] Costs vary by country/region based on one-time or annual adjustment factors (e.g., electricity price); therefore, the lowest and highest costs for the region are shown.

Table 4-9: Non Annex I Emission Reductions in 2020 and Break-Even Costs for Fire Extinguishing

Reduction Option	Break-Even Cost (2000$/TCE)[a] Discount/Tax Rate 4%/0% Low	4%/0% High	20%/40% Low	20%/40% High	Emission Reduction of Option (MMTCE)	Percent Reduction from 2020 Baseline	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
FK-5-1-12	~~$83.74~~ $74.79	~~$84.36~~ $75.24	~~$335.01~~ $263.22	~~$336.18~~ $263.98	~~0.13~~ 0.17	~~9.9%~~ 10.1%	~~0.13~~ 0.17	~~9.9%~~ 10.1%
Inert Gases	~~$81.29~~ $53.38	~~$114.30~~ $76.93	~~$414.31~~ $303.69	~~$486.93~~ $346.75	~~0.11~~ 0.13	~~7.9%~~ 8.1%	~~0.24~~ 0.30	~~17.8%~~ 18.2%
Water Mist	~~$126.10~~ $88.03	~~$219.85~~ $145.06	~~$529.82~~ $387.41	~~$740.97~~ $504.47	0.02	~~1.1%~~ 1.2%	~~0.26~~ 0.32	~~18.9%~~ 19.3%

[a] Costs vary by country/region based on one-time or annual adjustment factors (e.g., electricity price); therefore, the lowest and highest costs for the region are shown.

Table 5-2: Baseline HFC and PFC Emission Estimates from Solvents (MMTCE)

Region	2005	2010	2015	2020
United States	~~0.45~~ 0.44	~~0.49~~ 0.46	~~0.52~~ 0.50	~~0.57~~ 0.56
Non-U.S. Annex I	~~0.56~~ 1.56	~~0.57~~ 1.01	~~0.57~~ 0.53	~~0.58~~ 0.56
Non-Annex I	~~0.06~~ 1.16	~~0.09~~ 0.63	~~0.10~~ 0.09	0.12
Total	~~1.07~~ 3.17	~~1.14~~ 2.10	~~1.20~~ 1.13	~~1.26~~ 1.23

Note: Totals may not sum due to independent rounding.

Table 5-6: United States Emission Reductions in 2020 and Break-Even Costs for Solvents

Reduction Option	Break-Even Cost (2000$/TCE) Discount Rate/Tax Rate 4% / 0%	20% / 40%	Emission Reduction of Option (MMTCE)	Percent Reduction from 2020 Baseline	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
Retrofit	~~($134.18)~~ ($199.64)	~~($132.14)~~ ($196.62)	0.00	0.0%	0.00	0.0%
~~HFC~~ Convert to HFE	$0.00	$0.00	~~0.28~~ 0.20	~~49.7%~~ 36.2%	~~0.28~~ 0.20	~~49.7%~~ 36.2%
NIK Semi-Aqueous	~~$0.80~~ $1.18	~~$2.14~~ $3.18	0.03	5.0%	~~0.31~~ 0.23	~~54.7%~~ 41.2%
NIK Aqueous	~~$6.67~~ $9.92	~~$17.89~~ $26.63	0.06	10.0%	~~0.37~~ 0.29	~~64.7%~~ 51.2%

Table 5-7: Non-U.S. Annex I Emission Reductions in 2020 and Break-Even Costs for Solvents

Reduction Option	Break-Even Cost (2000$/TCE) Discount Rate/Tax Rate 4% / 0%	20% / 40%	Emission Reduction of Option (MMTCE)	Percent Reduction from 2020 Baseline	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
	~~($134.18)~~	~~($132.14)~~				
Retrofit	($199.64)	($196.62)	0.00	0.0%	0.00	0.0%
~~HFC~~ Convert to HFE	$0.00	$0.00	~~0.12~~ 0.08	~~20.7%~~ 15.1%	~~0.12~~ 0.08	~~20.7%~~ 15.1%
NIK Semi-Aqueous	~~$0.80~~ $1.18	~~$2.14~~ $3.18	0.06	10.0%	~~0.18~~ 0.14	~~30.7%~~ 25.1%
NIK Aqueous	~~$6.67~~ $9.92	~~$17.89~~ $26.63	~~0.12~~ 0.11	20.0%	~~0.29~~ 0.25	~~50.7%~~ 45.1%

Table 5-8: Non Annex I Emission Reductions in 2020 and Break-Even Costs for Solvents

Reduction Option	Break-Even Cost (2000$/TCE) Discount Rate/Tax Rate 4% / 0%	20% / 40%	Emission Reduction of Option (MMTCE)	Percent Reduction from 2020 Baseline	Cumulative Reductions (MMTCE)	Cumulative % Reduction from 2020 Baseline
	~~($134.18)~~	~~($132.14)~~				
Retrofit	($199.64)	($196.62)	0.01	10.5%	0.01	10.5%
~~HFC~~ Convert to HFE	$0.00	$0.00	0.02	~~20.7%~~ 15.1%	~~0.04~~ 0.03	~~31.2%~~ 25.6%
NIK Semi-Aqueous	~~$0.80~~ $1.18	~~$2.14~~ $3.18	0.01	10.0%	~~0.05~~ 0.04	~~41.2%~~ 35.6%
NIK Aqueous	~~$6.67~~ $9.92	~~$17.89~~ $26.63	0.02	20.0%	~~0.07~~ 0.06	~~61.2%~~ 55.6%